CHAPTER 8

FLEXIBLE PAVEMENT DESIGN

8-1. General.

Flexible pavement designs will provide the following:

a. Sufficient compaction of the subgrade and of each layer during construction to prevent objectionable settlement under traffic.

b. Adequate drainage of base course.

c. Adequate thickness above the subgrade and above each layer together with adequate quality of the select material, subbase, and base courses to prevent detrimental shear deformation under traffic and, when frost conditions are a factor, to control or reduce to acceptable limits effects of frost heave or permafrost degradation.

d. A stable, weather-resistant, wear-resistant waterproof, nonslippery pavement.

8-2. Design Procedure.

a. *Conventional flexible pavements.* In designing conventional flexible pavement structures, the design values assigned to the various layers are applied to the curves and criteria presented herein. Generally, several designs are possible for a specific site, and the most practical and economical design is selected. Since the decision on the practicability of a particular design may be largely a matter of judgment, full particulars regarding the selection of the final design (including cost estimates) will be included in the design analysis. For computer aided design, see paragraph 1-6.

b. *Stabilized Soil Layers.* Flexible pavements containing stabilized soil layers are designed through the use of equivalency factors. A conventional flexible pavement is first designed and the equivalency factors applied to the thickness of the layer to be stabilized. When stabilized materials meeting all gradation, durability, and strength requirements indicated in TM 5-822-4, and in chap ter 17 herein are utilized in pavement structures, an appropriate equivalency factor may be applied. Soils which have been mixed with a stabilizing agent and which do not meet the requirements for a stabilized soil are considered modified and are designed as conventional pavement layers. When portland cement is used to stabilize base course materials in Air Force Pavements, the treatment level must be maintained below approximately 4 percent by weight to minimize shrinkage cracking which will reflect through the bituminous concrete surface course. In this case, the base course will, in most instances, be modified rather than stabilized. In addition, when unbound granular layers are employed between two bound layers (e.g., an unbound base course between an asphalt concrete (AC) surface course and a stabilized subbase course), it is imperative that adequate drainage be provided the unbound layer to prevent entrapment of excessive moisture in the layer. Additional information on soil stabilization may be - obtained from TM 5-818-1.

c. *All-bituminous concrete.* All-bituminous concrete pavements are also designed using equivalency factors (see para 8-6). The procedure is the same as for stabilized soil layers discussed above.

8-3. Design Index.

The design of flexible pavements for roads, streets, parking areas, open storage, and similar areas will be based on a design index, which is an index representing all traffic expected to use a flexible pavement during its life. It is based on typical magnitudes and compositions of traffic reduced to equivalents in terms of repetitions of an 18,000-pound, single-axle, dual-tire load. Selection of the design index will be accomplished as stated in chapter 3. The designer is cautioned that in selecting the design index, consideration will be given to traffic which may use the pavement structure during various stages of construction and to other foreseeable exceptional use.

8-4. Thickness Criteria-Conventional Flexible Pavements.

Thickness design requirements are given in figure 8-1 in terms of CBR and design index. Minimum thickness requirements are shown in table 6-1. For frost condition design, thickness requirements will be determined from chapter 18 of this manual. In regions where the annual precipitation is less than 15 inches and the water table (including perched water table) will be at least 15 feet below the finished pavement surface, the danger of high moisture content in the subgrade is reduced. Where in-place tests on similar construction in these regions indicate that the water content of the subgrade will not increase above the optimum, the total pavement thickness, as determined by CBR tests on soaked samples, may be reduced by as much as 20 percent. The minimum thickness of pavement and base course must still be met; therefore the reduction Will be affected in the subbase course immediately above the subgrade. when only limited rainfall records are available, or the annual precipitation is close to the 15-inch criterion, careful consideration will be given to the sensitivity of the subgrade to small increases in moisture content before any reduction in thickness is made.

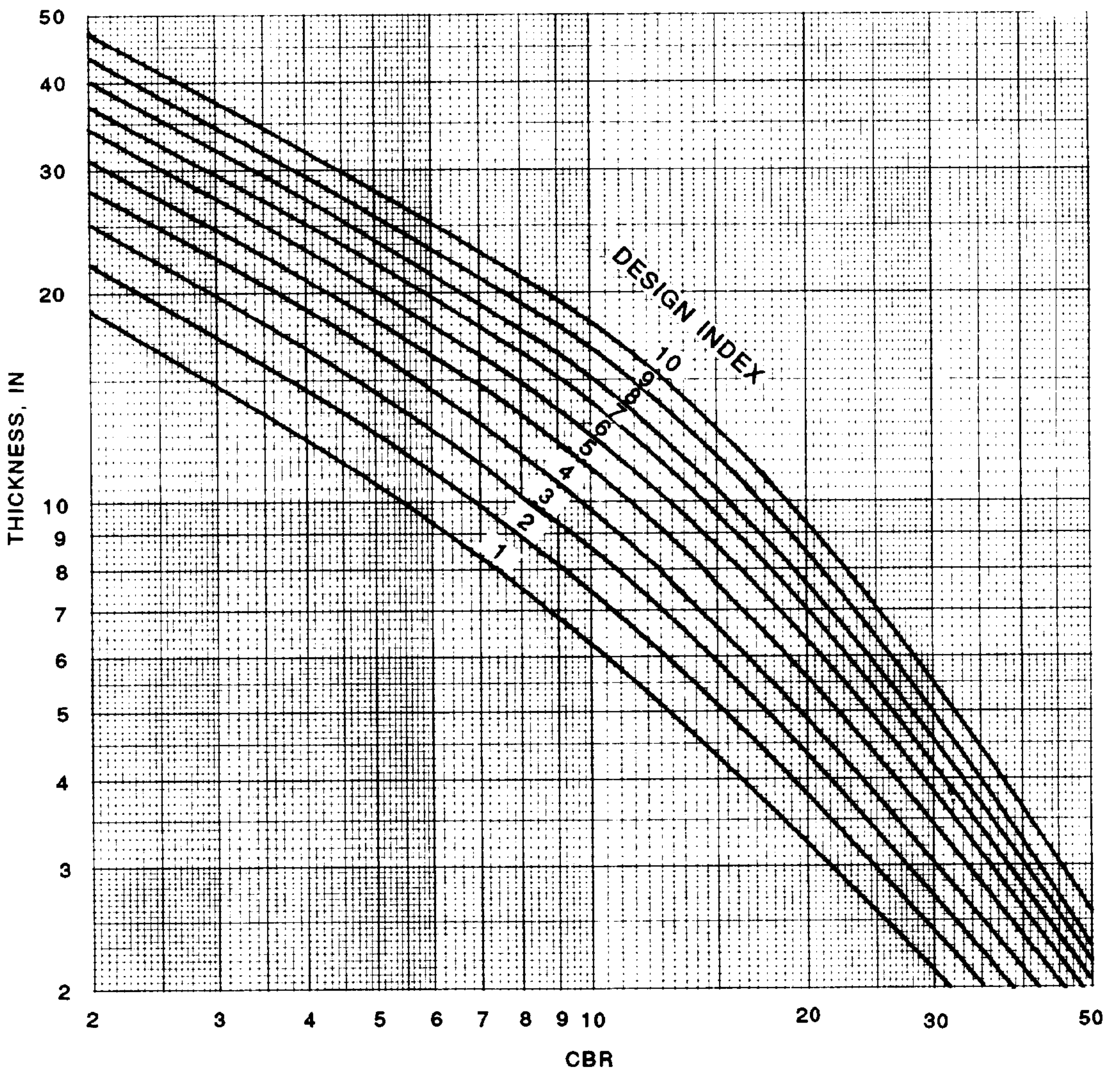

Figure 8-1. Flexible Pavement Design Curve for Roads and Streets.

8-5. Example Thickness Design-Conventional Flexible Pavements.

This example illustrates design by the CBR method when the subgrade, subbase, or base course materials are not affected by frost. Assume that a design is to be prepared for a road that will require a design index of 5. Further assume that compaction requirements will necessitate an increase in subgrade density to a depth of 9 inches below the subgrade surface and that a soft layer occurs within the subgrade 24 inches below the subgrade surface. The CBR design values of the various subgrade layers and the materials available for subbase and base course construction are as follows:

Material	Soil Classification	Design CBR
Weak layer in subgrade	CH	4
Natural subgrade	CL	7
Compacted subgrade	CL	10
1	GP	35
2	GM (limerock)	80

The total thickness and thicknesses of the various subbase and base layers are determined as follows:

a. Total thickness. The total thickness of subbase, base, and pavement will be governed by the CBR of the compacted subgrade. From the flexible-pavement design curves shown in figure 8-1, the required total thickness above the compacted subgrade (CBR of 10) is 11 inches. A check must be made of the adequacy of the strength of the uncompacted subgrade and of the weak layer within the subgrade. From the curves in figure 8-1, the required cover for these two layers is 14.5 and 21 inches, respectively. If the design thickness is 11 inches and the subgrade is compacted to 9 inches below the subgrade surface, the natural subgrade will be covered by a total of 20 inches of higher strength material. Similarly, the soft layer occurring 24 inches below the subgrade surface will be protected by 35 inches of total cover. Thus, the cover is adequate in both cases.

b. Minimum base and pavement thicknesses. For a design index of 5 the minimum base thickness is 4 inches and the pavement thickness is 2½ inches as indicated in table 6-1. If, however, the CBR of the base material had been 100 rather than 80, a minimum pavement thickness of 2 inches would have been required.

c. Thickness of subbase and base courses. The design thickness of each layer of materials 1 and 2 will depend upon the CBR design value of each material. The total thickness of subbase, base, and pavement, as determined above, is 11 inches. The thickness required above material 1 (CBR = 35), as determined from figure 8-1, is 3 inches; there- fore, the required thickness of material 1 is 8 inches (11 - 3 inches). The 3-inch layer required above material 1 will be composed of material 2 and pavement; however, adjustments must be made in the thicknesses of material 2 and the pavement to conform with minimum base and pavement thickness, which is a combined thick-ness of pavement and base of 6½ inches (2½ inches of pavement and 4 inches of base). Therefore, the section using materials 1 and 2 will consist of a 4.5-inch subbase course of material 1, a 4-inch base course of material 2, and a 2½-inch pavement.

8-6. Thickness Criteria-Stabilized Soil Layers.

a. Equivalency factors. The use of stabilized soil layers within a flexible pavement provides the opportunity to reduce the overall thickness of pavement structure required to support a given load. To design a pavement containing stabilized soil layers requires the application of equivalency factors to a layer or layers of a conventionally designed pavement. To qualify for application of equivalency factors, the stabilized layer must meet appropriate strength and durability requirements set forth in TM 5-822-4. An equivalency factor represents the number of inches of a conventional base or subbase which can be replaced by 1 inch of stabilized material. Equivalency factors are determined as shown in table 8-1 for bituminous stabilized materials, and from figure 8-2 for materials stabilized with cement, lime, or a combination of flyash mixed with cement or lime. Selection of an equivalency factor from the tabulation is dependent upon the classification of the soil to be stabilized. Selection of an equivalency factor from figure 8-2 requires that the unconfined compressive strength as determined in accordance with ASTM D 1633 be known. Equivalency factors are determined from figure 8-2 for subbase materials only. The relationship established between a base and subbase is 2 to 1. Therefore, to determine an equivalency factor for a stabilized base course, divide the subbase factor from figure 8-2 by 2.

Table 8–1. Equivalency Factors for Bituminous Stabilized Materials.

Material	Equivalency Factors	
	Base	Subbase
All-bituminous concrete	1.15	2.30
GW, GP, GM, GC	1.00	2.00
SW, SP, SM, SC	(*)	1.50

*Not used for base course material.

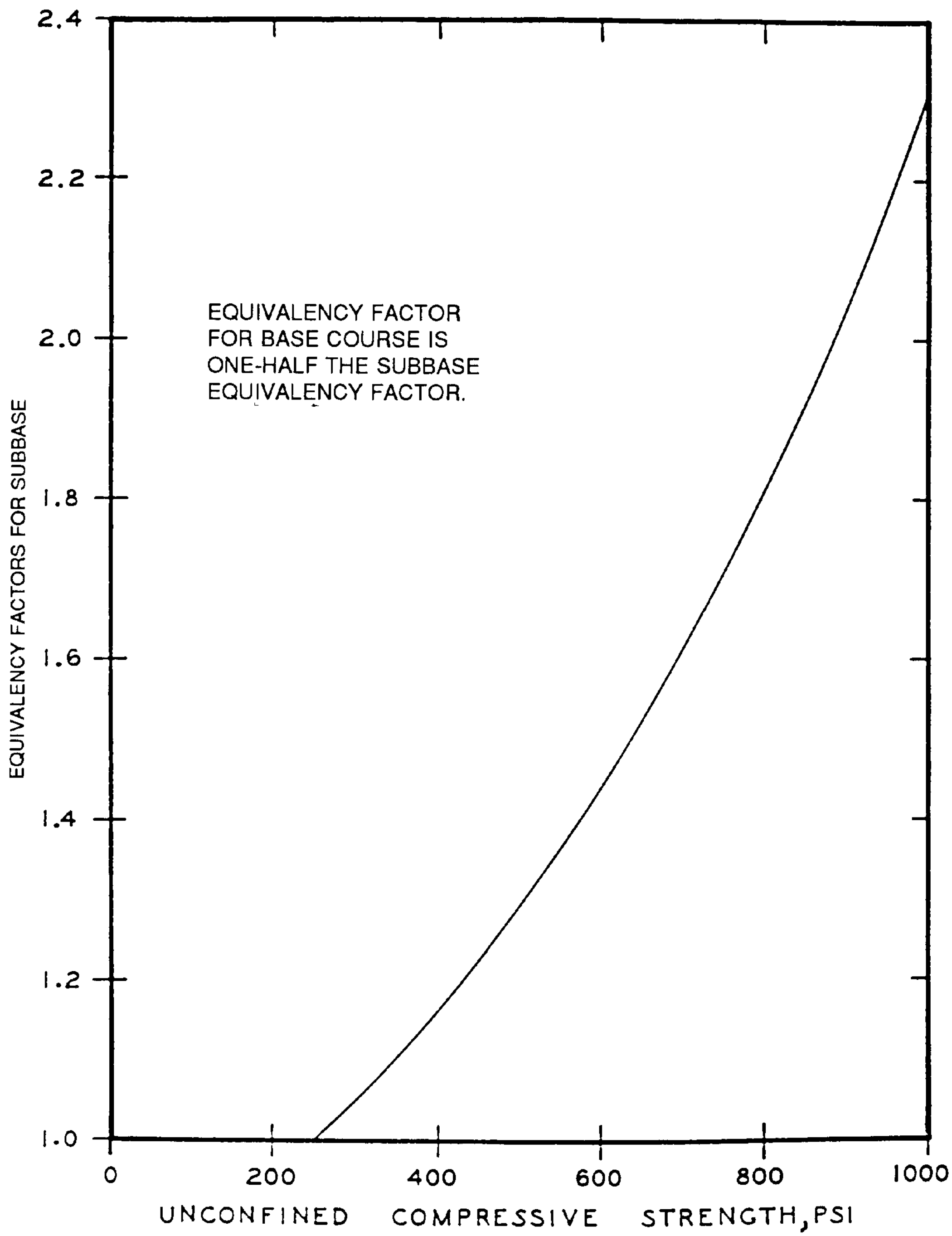

Figure 8-2. Equivalency Factors for Soils Stabilized with Cement, Lime, or Cement and Lime Mixed with Flyash.

b. Minimum thickness. The minimum thickness requirements for a stabilized base or subbase is 4 inches. The minimum thickness requirements for the asphalt pavement are the same as shown for conventional pavements in table 6-1.

8-7. Example Thickness Design-Stabilized Soil Layers.

To use the equivalency factors requires that a conventional flexible pavement be designed to support the design load conditions. If it is desired to use a stabilized base or subbase course, the thickness of conventional base or subbase is divided by the equivalency factor for the applicable stabilized soil. Examples for the application of the equivalency factors are as follows—

a. Example 1. Assume a conventional flexible pavement has been designed which requires a total thickness of 16 inches above the subgrade. The minimum thickness of AC and base is 2 and 4 inches, respectively, and the thickness of subbase is 10 inches. It is desired to replace the base and subbase with a cement-stabilized gravelly soil having an unconfined compressive strength of 890 psi. From figure 8-2 the equivalency factor for a subbase having an unconfined compressive strength of 890 is 2.0. Therefore, the thickness of stabilized subbase is 10 inches ÷2.0=5.0 inches. To calculate the thickness of stabilized base course, divide the subbase equivalency factor by 2 and then divide the unbound base course thickness by the result. Therefore, 4 inches ÷1.0 = 4.0 inches of stabilized base course. The final section would be 2 inches of AC and 9 inches of cement-stabilized gravelly soil. The base course thickness of 4.0 inches would also have been required due to the minimum thickness of stabilized base.

b. Example 2. Assume a conventional flexible pavement has been designed which requires 2 inches of AC surface, 4 inches of crushed stone base, and 6 inches of subbase. It is desired to construct an all-bituminous pavement (ABC). The equivalency factor from table 8-1 for a base course is 1.15 and for a subbase is 2.30. The thickness of AC required to replace the base is 4 inches ÷1.15=3.5 inches, and the thickness of AC required to replace the subbase is 6 inches ÷2.30 = 2.6 inches. Therefore, the total thickness of the ABC pavement is 2+3.5+2.6 or 8.1 inches, which would be rounded to 8.0 inches.

8-8. Shoulders and Similar Areas.

These areas are provided only for the purpose of minimizing damage to vehicles which use them accidentally or in emergencies; therefore, they are not considered normal vehicular traffic areas. Normally, only shoulders for class A roads will be paved. Others will be surfaced with soils selected for their stability in wet weather and will be compacted as required. Dust and erosion control will be provided by means of vegetative cover, anchored mulch, coarse-graded aggregate, or liquid palliatives (TM 5-830-3/AFM 88-17, Chap 3). Shoulders will not block base-course drainage, particularly where frost conditions are a factor. Where paving of shoulders is deemed necessary, the shoulders will be designed as a class F road or street.

8-9. Bituminous Sidewalks.

Permanent bituminous sidewalks will consist of a 4-inch-thick base with a 1-inch-thick bituminous surfacing. Material used locally in base construction for roads will normally be suitable as sidewalk base material. Bases may also be constructed of soils stabilized or modified in place with portland cement, lime, bituminous materials, or other acceptable stabilizers. In frost and permafrost areas, bases of sidewalks should be nonfrost-susceptible. The bituminous surfacing may consist of hot- or cold-mix bituminous concrete, sand-asphalt or sand-tar mixes, or sheet asphalt; in locations where the surface texture is not of prime importance, bituminous surface treatments may be used. Temporary walks or walks that are seldom used will be constructed of stable or stabilized soils or rock screenings containing granular and colloidal materials combined in the proportions necessary to ensure maximum density and stability under varied weather conditions, including frost action. Where necessary, the life of these walks may be prolonged by the application of bituminous surface treatments or by the addition of suitable stabilizing agents. The use of soil sterilants may be considered to prevent vegetation growth through bituminous sidewalks.

8-10. Bituminous Driveways.

Base course materials in residence driveway areas will be compacted to not less than 100 percent, and the top 6 inches of the subgrade to not less than 90 percent (95 percent for cohesionless sands and gravels) of the maximum density from ASTM D 1557. Minimum base course thicknesses for residence driveways are as follows:

Subgrade CBR	Base course minimum thickness inches
Greater than 7	4
5 to 7	6
Less than 5	8

The minimum paving requirements for residence driveways are a multiple bituminous surface treatment for base course CBR values less than 80 and a single-bituminous surface treatment for CBR values of 80 or above.

8-11. Curbs and Gutters.

Curbs and gutters will be provided with a foundation at least 4 inches thick of material of 50-CBR minimum. The material will be nonfrost-susceptible when required and will be compacted to the same requirements as the base or subbase course at the same elevation. The foundation for curbs and gutters will not block the drainage of base course (TM 5-822-2/AFM 88-7, Chap 5).

8-12. Flexible Overlay Design.

For the design of flexible pavement overlays, see chapter 14 of this manual.